Learnings

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Abstract

This chapter reports on learnings gained from the industrial cases (Chaps. 4 and 5) and on a more general level on learnings related to sensing. Doing so, the generic steps and stakeholders involved within the two different cases are described and for each activity bundle respective learnings are reported. Aside from the procedural reflection, learnings from the regional consulting partners within the cases are described on a general level. In addition to the case learnings, learnings with respect to sensing human and machine properties are reported. As such the

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chapter is intended to inform practitioners about crucial aspects to be considered, lessons learnt in the different activities of the cases and suitable method support or enrichment regarding the different S-BPM activities.

7.1 Learnings from the Industrial Cases

The industrial cases presented in Chaps. 4 and 5 reported on the application of S-BPM in two different settings. The first one focusses on digitizing the production process in a vertically integrated manner, whereas the latter supports employee involvement in workplace improvement. However, both cases applied a similar project approach which will be discussed and reflected with respect to learnings in this section (Fig. 7.1).

The case implementations represented an international and multidisciplinary endeavour. Stakeholders of the cases included

- Case Companies (management and employees/workers)
- Regional consulting partners
- R&D department of technology providers (S-BPM tool provider, MoKi collaboration tool provider)
- Sensor developer
- Human-centred design and evaluation consultant
- Process management researcher
- Funding agency (European Commission)

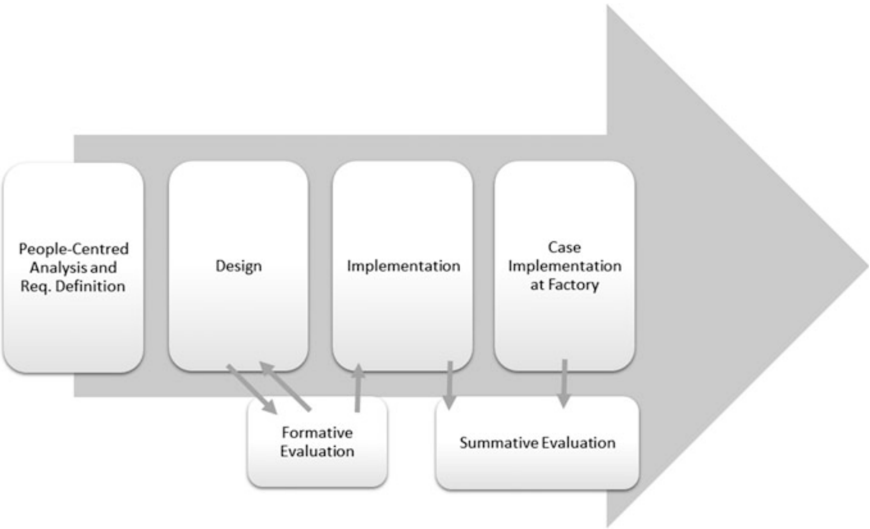

Fig. 7.1 Generic steps taken within the industrial cases

Subsequently, learnings within the different activity bundles are reported. Furthermore, observed interdependencies are discussed in this section. Finally, general learnings from the cases are presented.

7.1.1 People-Centred Analysis and Requirements Elicitation

The cases aimed to gain deep insights into work practices and needs of people at their workplace in order to enable respective solution design. Thus, a procedure has been applied which builds upon accepted frameworks and models in the field of human-centred design (cf. Maguire 2001), Requirements Engineering (cf. Paetsch et al. 2003; Dean and Don 2003) and Subject-Oriented Business Process Management (cf. Fleischmann et al. 2012).

Basically, the procedure consists of three activity bundles—(1) Analysis of organizational improvement potentials, (2) Use case definition, (3) Requirements elicitation—that may be conducted iteratively in order to elicit and design appropriate solutions for future production workplaces (Fig. 7.2). Within the initial analysis, on-site observations and interviews with employees have been conducted to gain knowledge about the as-is situation and first insights into desired to-be situations. Aside, a brainstorming session with the management of each industrial partner has been conducted to identify suitable use case candidates and opportunities for organizational improvement. Use case candidate descriptions comprise involved stakeholders and workplaces, the motivation and opportunity and initial improvement ideas from workers and management. Each potential improvement has been assessed along several dimensions: Process automation, people-centredness, management impact, production efficiency, application potential of S-BPM for communication and execution support and level of involvement of the project partners. These assessment dimensions stem from overall, high-level project goals, topics relevant to the funding agency and company needs.

Learnings related to the analysis of organizational improvement potentials are

- Encourage open-minded ideation
- Carefully observe workplace context to identify relevant influence dimension for solution development (e.g. culture, environment, social interdependencies, …)

Based on the knowledge gained from the initial analysis, in a second step a concrete use case has been derived. Such a use case description is composed of, according to Kliem et al. (1997): (1) Motivation and Opportunity, (2) Goals and Objectives and (3) Scope of the case, including boundaries to stakeholder and related systems. Additionally, the description has been enriched with a high-level S-BPM process model to illustrate the involved actors and their collaboration. The case definition was supported by the use case dimensions given above. Especially

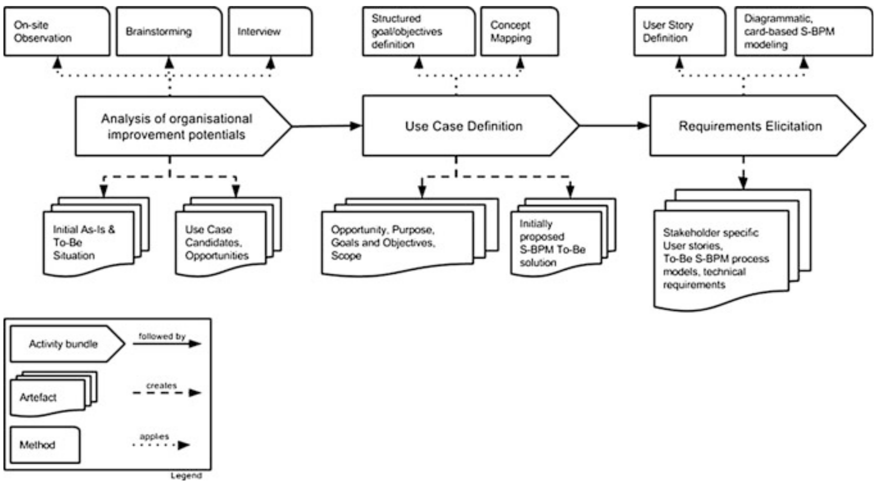

Fig. 7.2 Generic elicitation and design approach in the industrial cases

the goal and objective definition with multiple stakeholder from different fields turned out to require support for the structured collection and alignment of use case goals and objectives.

Goals and objectives were collected in a table structure by each stakeholder. This step resulted in a set of goals and objectives of different stakeholders. Since the results were overlapping across different stakeholders and the granularity of the different inputs varied, a consolidation of the collected goals and objectives was necessary to reduce duplicates and align different points of view. Thus, Concept Mapping has been applied to identify replications and depict relationships between goals and objectives. Concept maps structure knowledge in the form of nodes and edges. Concepts represent a subject (area) or metaphors and are related to one another by edges. As they represent relationships, each relation needs to be named. The Concept Mapping resulted in a consolidated list of goals and objectives of the respective case.

Learnings related to the use case definition:

- Sole provision of the definition of the terms "goal" and "objective" is not sufficient for a distributed, multi-perspective procedure to collect goals and objectives. A shared understanding related to both terms needs to be developed before in order to reduce diverse levels of granularity. Active discussion of results and synchronous alignment is recommended
- Collaborative, multidisciplinary goal and objective definition requires careful alignment among stakeholders. The consolidation of results needs to be comprehensible for stakeholders

The documentation gained from the first two activity bundles was reformulated by the management and the project team in terms of user stories, in order to specify functional requirements for that case. User stories follow the idea to formulate a requirement in terms of the sentence structure 'who—wants what—why' and they are used to structure implementation tasks in the context of agile software development. To ensure the alignment with the end users, the user stories were validated with them. Additionally, workers were able to formulate further user stories. Based upon these requirements an S-BPM implementation could be developed. The S-BPM models were created by applying a diagrammatic, card-based S-BPM modelling approach in the first step. The card-based modelling does not require IT support and aims for involving process participants in modelling. However, the card-based approach was supported by an S-BPM tool subsequently. Since the resulting models can directly be executed, it could be validated with the end users in a kind of role play allowing the identification of errors or hot spots for further improvement.

Learnings related to the requirements definition:

- User stories represent a simple means to define functional requirements. However, the specification process needs to be moderated and supported in order to ensure an adequate level of granularity
- User stories and S-BPM process specifications need to be aligned. When modelling keep in mind the defined user stories. Furthermore, map user stories to new process designs and perform a consistency check
- The defined and agreed-upon user stories need to be considered as dynamic entities! The current list of user stories should be made available for all stakeholders, in order to encourage active discussion among them
- User stories need to be actively considered in later project stages as baseline for task accomplishment

People-centred requirements elicitation depends amongst others on the context of the requirements elicitation at a specific time, like the dependencies of workers on the ongoing technological developments and the dynamics and changes in management affecting the solution or use case itself. This context should be taken into account to balance the organizational requirements (use case scoping, organizational changes during the project), the elicited functional people-centred requirements and the state of the technical development and requirements over a long development period, as the 3 years of the project in hand.

Hence, an integrated requirements and project management framework is considered to be helpful. Such a framework should comprise existing dependencies between the use case context, the technology development and the people-centred requirements stated by the workers. Its implementation should involve all the stakeholders at key points of the development to monitor the project setting and situation related to the people-centred requirements analysis, in order to ensure that people-centred requirements engineering is not influenced by any managerial, organizationa, or technological issues during the project lifecycle.

7.1.2 Informed Subject-Oriented Process Design and Implementation

The defined use cases for each industrial partner, the identified functional requirements in terms of user stories and the organizational requirements in terms of a high-level to-be S-BPM process model represented the initial reference point for the solution design. In the first step, the development and regional consultant partners created mock-up prototypes for the desired user interfaces. Furthermore, the S-BPM models were refined by the process and development partners.

In order to inform the design process and ensure that the project meets user expectations, formative evaluation activities were conducted. In developer workshops, the development and consulting partners mainly aligned technical issues regarding the design and implementation of the desired solution, whereas the focus groups were intended to receive feedback from the actual users. The involvement of operative stakeholders in the process design and validation contributed to the development of a shared understanding and targeted towards qualifying employees in subject-oriented modelling.

The project team consisted of several stakeholders, in order to collect different know-hows. Management had a holistic understanding of the company and delivered valuable input to optimization potentials, relevant applications and different solutions. In addition to that, the management represented customer needs. Production workers contribute to providing local optimization potential, requirements and feedback on possible solutions from the user perspective. The regional IT consulting partners accompanying the project were responsible for introducing solutions, gathering feedback and ensuring the project implementation on-site at the industrial partners. Research and development partners contributed to innovate solution and evaluation designs.

In general, the project team considered early prototyping and user-led design and implementation as vital for the project's success. Without continuously showing and explaining new technological solutions, it is difficult for people to envision the possibilities of a new solution and to indicate requirements and advices during the development. Thus, early prototyping and tool training are essential for the knowledge transfer. Furthermore, it may serve to showcase the possibilities of the technology to future users in an early stage and to create a common vision.

Informed by the results of the focus groups more advanced prototypes were created for the industrial cases. These prototypes were actually tested within concrete user tests investigating the usability, usefulness and acceptance of developed solutions. Again, the outcome informed the development team within the implementation activities.

Learnings related to subject-oriented (process) design:

- Blending S-BPM models with user interface mock-up prototypes is beneficial for fostering a shared understanding between users and developers

- The generic Metasonic workflow support user interface was deemed too complex to be used by shopfloor workers. Customization of user interfaces enabling the provision of easy-to-use interfaces is vital to stakeholder acceptance
- Modelling S-BPM with actual users needs to be carefully moderated and guided

Although S-BPM comprises a limited set of modelling symbols, it may not be the best or the easiest modelling approach to be used. Its benefits and drawbacks have to be evaluated involving the specific target users and checking the project's purpose (Fig. 7.3).

Learnings related to formative evaluation:

- Clear documentation of evaluation results as well as the definition of consequences and measures for the implementation supports the alignment with user needs
- User involvement contributes to a shared understanding of user needs and adequate solution design
- Formative evaluation activities were observed to be beneficial for:
  - Management commitment
  - Discussion of different support aspects for certain groups of users
- Workshops should provide sufficient time and space for testing and feedback articulation, in order to avoid that participants have only a limited amount of time and do not really engage in evaluation activities

The implementation in both the cases has been tailored to the capabilities and needs of the specific companies. The focus in company A was to digitize the production process and integrate sensors in order to facilitate real-time production state tracking. As such, the implementation required the collaboration of regional IT consultant, the S-BPM tool provider, the hardware developer and the S-BPM research team. Within developer workshops, interfaces and technical issues were aligned within the team. Individual modules, such as location tracking or power

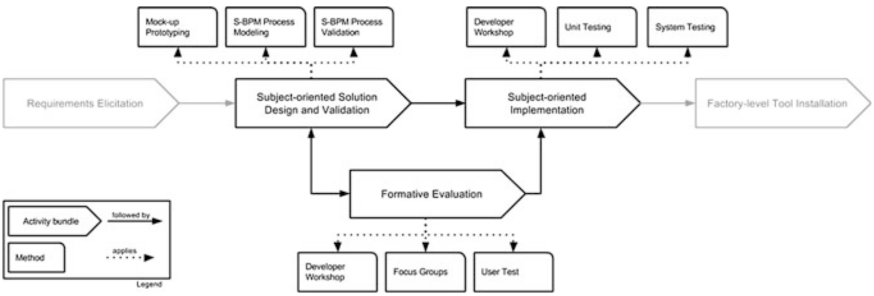

Fig. 7.3 Design and implementation activities

metering were tested within different unit test in order to ensure the provision of appropriate functionality. Furthermore, the integration of the diverse components has been tested within system tests. The implementation also comprised interfacing existing systems of the company. However, company A introduced a new ERP system during the implementation phase. Modified interface definitions and missing interfaces for the required solution delayed the implementation and caused additional alignment effort.

In company A, research prototypes for integrating sensors in S-BPM processes have been applied and tested as part of the implementation (OPC UA template, location sensing service). Furthermore, customizing S-BPM user interfaces has been tested in a productive setting for the first time.

Learnings related to the implementation relevant for company A:

- Process designers and implementers need to understand semantics of sensor data that are used within the process
- Synchronisation between the business process (workflow) engine and the real-time engine needs to be carefully investigated and decided upon a case-by-case basis, e.g. when implementing push or pull notifications
- Customizing user interfaces according to the approach of Kannengiesser et al. (2016) is vital. However, the customization needs to be done by experts and is hardly understood by domain users

In company B, the S-BPM tool provided by Metasonic has been integrated for the first time with the MoKi collaboration platform. The Metasonic tool functionalities for modelling and executing S-BPM process models have been combined with the MoKi functionalities for the collaborative user-friendly modelling of (structured and unstructured) knowledge. The focus in company B was supporting the company's suggestion process, by enabling workers to report issues and provide suggestions about their workplace, managers to provide feedback, analyse data and make decisions and all of them to discuss and keep track of problems and potential solutions.

Learnings related to the Metasonic-Moki integration:

- When two or more existing technologies, possibly providing multiple features, need to be integrated, it is important to clearly define the contribution (in terms of functionalities) of each of them in the resulting integrated technology, starting with the initial design steps
- The communication among different existing software should be as much decoupled as possible from proprietary and low-level solutions, which are not flexible and require intense maintenance operations. In these cases, it is important to design communication based on commonly agreed and flexible interfaces (e.g. service-based communication, message bus), and interoperable exchange formats
- When integrating different tools, possibly each offering its own user interface, users have to be provided with an adjusted or unique interface (e.g. the user

interface of one of the tools, a completely new user interface, or an interface embedding the others), minimizing extra learning effort, and avoiding confusion due to different user interface elements

Learnings related to the solution implementation:

- Involving real users of the implemented tool in the design of the user interfaces is of the utmost importance. Indeed, different devices and user expertise with common usage patterns (e.g. tablet interactions vs classical keyboard/mouse interaction) affect the acceptance
- S-BPM processes that have to be executed, when describing human behaviours, have to be designed in a flexible way to take into account a number of exceptions and errors that can occur when dealing with human procedures (requiring rolling back operations)
- Avoiding duplicate and scatter information in different repositories is fundamental for maintenance and general applicability purposes
- Adopting simple solutions is to be preferred in industrial environments because it allows meeting scalability requirements in a more convenient way

7.1.3 Factory-Level Tool Installation

The factory-level tool installations in company A and B comprised the organizational and technical setup of the solutions developed for the defined cases. These activities were performed by the regional consulting partners and the technology providers. As key take-aways they reported the following observations:

- Always test the system in the actual field with actual users:

  - Network quality, network configurations, email-server configurations, different end-user devices may cause unexpected behaviours when switching from the test to the live system
  - Users do not always behave as developers would expect them to do

- Shop floor conditions may influence asset tracking. For instance, in the case of company A, the configuration of the signal strength with respect to different workplaces was carefully tested on-site
- Ensure an adequate hardware environment for the productive use of the developed technologies, avoiding the usage of outdated test machines

7.1.4 Summative Evaluation

Summative evaluation reported in both the cases on findings related to the outcome of the actual case implementations. For each case implementation, the technology acceptance, the achievement of goals and objectives and the people-centredness of the provided solution were investigated based on an individually developed case evaluation framework. The following key take-aways have been observed by the solution developers, evaluation designers and evaluators:

- Evaluation designers need a clear understanding of the solution provided and the relationship to the case goals and objectives. Hence, close cooperation with solution developers when designing the evaluation framework is recommended
- Evaluation designers need to closely work together with actual (regional) evaluators in order to ensure that evaluators are aware of the evaluation object and the method
- The documentation of the evaluation results should be supported by evaluation designers. Validation of results by multiple stakeholders is recommended

7.1.5 Consultancy Learnings Reported Within the Cases

In addition to the above given case learnings related to the different activity bundles performed, general learnings from the regional consulting partners have been reported and are described in terms of principles to follow in such projects.

7.1.5.1 Learnings Related to Company A

Continuously discuss the project progress with the company management

Company A has, within the project implementation, experienced changes on the management level. Due to the effort to increase the production and efficiency, crisis managers were hired. New managers (in conclusion hired for just a short period) seemed not always to be familiar with the impact the project should create. Therefore, they did not support the project implementation adequately. For future, it is advisable to permanently discuss the project course with management and precisely present the project impact on the current as well as on future production.

Gain feedback from a sufficient number of users to avoid individually customized solutions

Company A experienced changes on different levels of operation within the project implementation. Especially in the last phase of the project the company had to deal with changes of the staff's structure. Some employees have been affected by salary decreases and therefore decided to quit—among them at least three workers previously involved in the solution design. Thus, employees evaluating the developed solutions who were not involved in depth in the project could have missed the complete information on the project aspect—mainly its potential benefits. Those employees may perceive the developed case rather of low additional benefit, and thus, resistance to the new approach may become evident. Therefore, the involvement of an extended group of potential users (not only 5) is recommended to continuously validate the solution design and implementation.

Engage shop floor workers

A core topic of the case has been “people-centredness”. The consulting and industry partners have made a maximum effort to involve all relevant workers, especially shop floor workers. It can be stated that shop floor workers have been involved in the project implementation as originally envisioned. However, the continuous presentation and discussion of the project progress with the shop floor has been observed as a crucial element for project success. To some extent, the communication could have been too focused on the high management, neglecting the workers.

Carefully introduce technologies that might be used to monitor workers

Some of the implemented features can be used for “worker monitoring”. When perceived by workers (e.g. power consumption, time monitoring, etc.), such features need to be discussed with them and the usage of the data as well as the security of the data needs to become transparent. Otherwise, resistance towards such solutions could rapidly come up.

Reserve sufficient time for feature testing

Although the project set out enough time for testing, some of the features were not used to an extent enabling conclusions. Moreover, some of the features show their impact and benefits on a long-term basis. Potentially, more time for comprehensive testing and deficiency correction should have been planned, as it could have increased the perception of employees being involved. The evaluation process could have been carried out within the testing process repeatedly, enabling to monitor the employees’ perception in time.

Closely cooperate with providers of existing systems and their interfaces

During the project implementation, Company A implemented a new ERP system. Some system features collided with the proposed solutions and, to a certain extent, affected some of the project activities. It would have been beneficial for the regional consulting partner to be involved in the analysis sessions between company A and the ERP provider in order to align overlaps, interfaces and conflicts.

Continuously update and review use cases and solution ideas

In an initial phase, use cases were defined. However, the project design and implementation covered the period of almost 3 years including changes affecting different elements of company A. For instance, management changes, changes in management commitment, staff layoff and economic issues of the company could all have had an effect on the initially envisioned solution. Thus, company requirements must not be considered static, they rather present a dynamic element that needs to be tackled as such to create stakeholder value.

7.1.5.2 Learnings Related to Company B

Involving users from the beginning of the project increases their willingness to participate

The people-centred approach adopted from the initial phases of the project and the involvement of the workers in the analysis and design phases supported the project participation in terms of motivation and commitment. Both, Company B management and workers declared that such an active involvement allowed for the creation of something actually useful and helpful for their daily working experience.

Formative and case evaluations are useful:

Formative and case evaluations are useful for a twofold purpose: (i) supporting the system development and iterative refinement; (ii) user-centredness. On the one hand, they provide an effective means to support the development process, starting from the design of the system up to its iterative refinements as well as actual advantages for the case. Since the perception a developer has of the to-be system is likely to differ from user expectations, early feedback and iterative development supported the alignment between users, the organization and the development. On the other hand, the involvement of workers in the suggestion and evaluation phases, and the importance given to their feedback, increase their understanding of the system as well as their motivation towards the system usage.

Furthermore, the following aspects of the formative and case evaluation activities were observed to be beneficial

- Management commitment
- Discussion of different support aspects for certain groups of users (to develop a common understanding)
- Sufficient time for workshops (thus avoiding that participants have only a limited amount of time and do not really engage in the evaluation activity).

7.2 Learnings Related to Sensing

7.2.1 Human Sensing

The experiences gained within the sensor-related investigation of the authors revealed the fact that when sensors that are worn by workers in order to determine something about their status as a result of physiological measurements, widespread adoption will require that the workers believe that the end objective is not only good for productivity but also good for the work force.

The accuracy rating of data coming from a sensor must be very high if instantaneous changes in a workflow are going to be performed automatically as a function of the sensor data. Since the interrelationship between physiological responses and mental state is very complex, the analytical treatment of the sensor data must also achieve very high classification accuracy if it is to be used in real time.

At this stage it appears that the risk of upsetting workers (privacy intrusion) and the risk of upsetting a workflow (due to inaccurate sensor and data analytics) can be minimized by using data over longer periods of time, in such a way that it can be partly anonymized, inaccuracies can be reduced as outlier, and unacceptably noisy data are removed from the processed data.

Human sensors also need to be treated within the context of the “big picture”. The attraction of human sensors is to allow automatic systems to gain some insight into the working life of the employee. As an example, take the case of a good shop floor manager who keeps a close eye on an employee working in production. Applying his intuition, experience and empathy the manager can detect when the employee is stressed and the manager can try to improve the work conditions by changing the workflow or training. The manager does not only see stress in the employee’s visage, but also knows the man’s experience on the job and his temperament, for example he takes longer to learn but once he does he excels. He knows the jobs the worker is on and he knows they are very difficult to perform.

To match the capability of the manager, the sensors need to be combined with other information so that a full picture is built up. Worker Stress + worker experience + workers current jobs + complexity of those jobs.

Thus the human sensor has its place, inside a large labyrinth of extra data, and to achieve automated high-level semantic conclusions, data from many sources over long time is needed. If not, then only very simple almost trivial analytics will be achievable.

7.2.2 Asset Tracking

Although during the developments of Company A a tag sensor with many inbuilt functions was built, it appears that in the face of diverse applications (ranging from many different types of production method to many different features associated with each asset) tags need to be much more diversified to fit in closely with a given domain or specific product or service.

Certain key electronic functions can be retained as standard such as memory, primary sensing and communications.

However the diversity will come in

- The embodiment of the electronics (for example into packaging)
- The physical way in which humans will probe the tag
- The physical way in which machines will probe the tag
- The tag deployment and recycling infrastructure

- Tag data security
- Cost benefit

In fact it would seem that consultants could create commercial consultancy services purely to address these topics.

From the point of view of the necessary middleware-software systems processing data from sensors, data analytics could be kept very simple with limited need for complex algorithms. Instead databases could simply be generated showing the data and making it available for querying by other applications when necessary. Thus, the software systems could be very light and even adopt an Internet of Things model for scaling up towards many millions of assets.

Probably the biggest benefit of tagging in this way would come from the ability to make sweeping observations about wastage in the process or the organization (e.g. finding out why so many items are perishing from heat or identifying quality failure issues early in the production process). In this case visualization of the big sensor data could allow human decision-makers to identify financial savings.

This concept was considered in a use case related to a bakery where cream cakes were either being over produced or under produced leading to wastage or lost sales. In this use case, very low cost tags could have been used as part of the product packaging. This would allow a fully automatic and accurate real-time stock control to be applied across several retail outlets across a large geographic area. This data could lead towards improved prediction of demand and just in time cake production.

7.2.3 Machine Usage Profiling

While tags on assets can provide status information, there is a limit to which the internal workings of a machine (e.g. a CNC machine) can be inferred or understood by the production modelling system. During the developments it became clear that many production CNC machines do not expose their internal workings, for example by providing status information, by way of a computer connection. Clearly, this will change as such a feature is seen as useful. However, intelligent features may not be provided in all production machines, and there remains a large number of legacy equipment in factories across the EU.

At the same time we realized that energy consumption in factories is an important issue, to be monitored in order to reduce costs. By combining these two ideas, we decided to use the monitoring of power to a machine as a means to infer the status of a machine through the way it uses power in real time as well as the overall level of total power consumed per week or month.

Doing so, a commercial OPC UA-enabled solution for non-invasive power metering was applied. This solution offered Ethernet connectivity and immediate CE approvals which meant they could be deployed on industry machinery with no risk to safety.

What we learnt was that deploying energy sensors in fully up and running factories requires special health and safety considerations that should not be underestimated. In several cases, it was not easy to interfere with the installations and installing the sensors required a multidisciplinary team of electrical and computer staff as well as management with health and safety in the loop.

Interfacing the energy monitors for each of the machines was achieved after relevant data exchange protocols were adhered to, and then real-time data of current consumption could be measured in real time via OPC UA.

The main idea behind energy monitoring is to look at the way the electrical power changes in real time during very short bursts as well as on average. Rotating electrical machines at first takes large amounts of power to achieve the high rotational speeds. Thus, at start up and within a few seconds the power profile is peaked and remarkable. However, with no load except friction the CNC machines reach a steady state of power consumption that is very low. The rotating parts usually have a very high rotational inertia and very high rotational momentum achieved once running at full speed. Therefore, when a tool begins to cut into a metal part at high speed the extra power to achieve the cut is comparatively small and perturbations are also very small having been filtered by the large rotational momentum.

Resistive electrical loads like ovens and boilers provide much simpler energy profiles. General automation based on DC servo motors and frequent load changes also are easier to characterize. Valve solenoids combined with pressured hydraulics or pneumatics are more difficult to model as the electrical pulses and compression system cannot be easily logically related without a clear idea about the different behaviour modes.

In a situation such as our CNC machine use case, while it is possible to detect the run up and run down of the machines, more subtle changes require a very high resolution power detection. Even when providing this information, it is necessary to correlate the energy changes with different workflows.

Therefore, we have learnt that energy power consumption can be used very simply for example to detect if the machine is switched on or off, and when in use. In order to determine more extensive features of the machine's status, it is necessary to be able to detect at high sample rate more subtle changes in the power consumption.

7.3 Conclusion

This chapter reflected on learnings regarding the application of S-BPM in two industrial cases aiming for people-centred production. Concluding, three core aspects of people-centred production shall be highlighted:

- Complexity needs a participatory approach and stakeholder knowledge
- Early participation of stakeholders
- Transparency of solution designs for all stakeholders from top to bottom

The increasing complexity of work demands for highly qualified employees and mutual alignment for task accomplishment. As such employees represent important stakeholders for work design and need be involved in solution design and implementation. Especially early participation when defining workplace requirements seems beneficial for sustainable solution designs. Furthermore, the transparency of solution designs for all stakeholders needs to be ensured from top to bottom in order to avoid resistance and resolve conflicts early. Transparency can be supported by active communication of project results via different channels (face-to-face, presentations, newsletter, social media, …). Transparency of solution designs has also been identified as crucial related to the implementation of sensor technology at workplaces. For humans sensors smack of supervision. Therefore, the "ingredients" of sensor solutions (e.g. usage of data, added value) need to be clear and aligned among all stakeholders.

References

Dean, L., & Don, W. (2003) *Managing software requirements: A use case approach*. Addison-Wesley Professional.

Fleischmann, A., Schmidt, W., Stary, C., Obermeier, S., & Börger, E. (2012). *Subject-oriented business process management*. Berlin: Springer.

Kannengiesser, U., Heininger, R., Gründer, T., & Schedl, S. (2016) Modelling the process of process execution: A process model-driven approach to customising user interfaces for business process support systems. In *International Workshop on Business Process Modeling, Development and Support* (pp. 34–48). Springer International Publishing. doi:10.1007/978-3-319-39429-9_3.

Kliem, R. L., Ludin, I., Robertson, S., & Ken, L. (1997). *Project management methodology—a practical guide for the next millennium*. New York: Marcel Dekker.

Maguire, M. (2001). Methods to support human-centred design. *International Journal of Human-Computer Studies, 55*(4), 587–634. doi:10.1006/ijhc.2001.0503.

Paetsch, F., Eberlein, A., & Maurer, F. (2003). Requirements engineering and agile software development. In *Proceedings of WETICE'03*. Washington, DC: IEEE Computer Society.